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ABSTRACT

This publication is an information source on energy for teachers. The information in this publication is factual, and designed for courses of study about energy. This book has been divided into separate energy-related sections. Each section ends with a list of student participation discussion activities. The sections present facts about: (1) energy and its use; (2) oil and natural gas; (3) coal and hydropower; (4) nuclear energy; (5) energy used for transportation; (6) future energy sources; (7) electrical power sources in the TVA area; and (8) energy conservation. A glossary of terms is also provided. This publication was designed as a teacher's resource, not as a curriculum guide. The activities suggested are more appropriate for junior and senior high school students. (MR)

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INTRODUCTION

All conventional energy resources are in short supply—a problem touching all of us. But today's students are, perhaps, the hardest hit by the energy shortage. They are tomorrow's consumers, and there might not be enough energy to go around in the future.

The Energy Primer has been developed—not as a curriculum—but as a capsuled source of reference material about energy for teachers. The information in this publication is factual, and instructors are urged to use it in courses of study about energy, including mini-courses.

To help you, the teacher, this book has been divided into separate energy-related sections, each one ending with student participation and discussion activities. Also, energy terms used in this publication are defined in a glossary.

Hopefully, *The Energy Primer* can help you stress to your students the importance of energy in everyday life, problems connected with energy, and the need to make the future energy secure.

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I. FACTS ABOUT ENERGY AND ITS USE

The Importance of Energy

Energy is a fundamental part of the universe. It is found literally everywhere: inside and on the surface of the earth, in the surrounding atmosphere, and in space.

According to its basic definition, "energy is the ability to do work or the capability to produce a change in temperature." However, when someone uses the word "energy," he or she generally means the primary energy sources or fossil fuels: oil, natural gas, and coal.

Although the sun is earth's most important and abundant energy source, man has relied heavily on the primary energies for his existence and the advancement of civilization. These primary energy sources were formed from plant and animal life that thrived eons ago, then died, and became fossilized in the earth's crust.

Everything requires energy; it is all-important. The human body gets energy from food, giving it the strength to exert its own energy. Plants have to have the sun's energy. And since all consumer items are manufactured by energy use, America's high standard of living—any standard of living—is directly linked to its energy supply.

Americans have come to take present lifestyles and readily available energy for granted. Most people have no comprehension of how much energy is consumed to make and market a seemingly simple, everyday consumer product—a glass of orange juice, for example.

Some form of energy was used to plant the orange trees. Oil and gasoline or diesel fuel ran the farm machinery that helped maintain the orange grove. The trees had to be fertilized and sprayed. Not only did that require energy, but the manufacturing and transportation of chemicals and equipment used depended on energy. It took energy to harvest and transport the oranges to a processing plant, where they were pressed into juice, which was then packaged and frozen or bottled by another process requiring energy. And, if the juice was frozen, energy was used to keep it frozen.

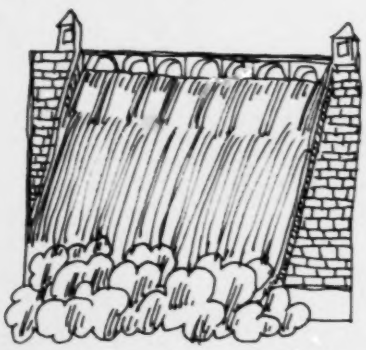
Then in containers, the juice had to be distributed, which also incorporated various forms of energy use. To obtain the orange juice from grocery stores, consumers probably used a car, fueled by gasoline, as their mode of travel. Once in the home, the juice was kept chilled in an electric refrigerator. And the glass from which the juice was drunk went through a manufacturing process that also required

a lot of energy.

So much energy is needed to provide the most commonplace things, such as a glass of orange juice, that when one tries to consider the total energy consumption used to make up the physical environment, it boggles the mind.

The Categories of Energy

There are two broad categories of energy: potential and kinetic. Moving things carry kinetic energy. For instance, water droplets in a waterfall have kinetic energy because of their motion. Potential energy is stored energy an object has because of its position. Water at the top of a dam has potential energy. But if the water is allowed to spill over or through the dam, the potential energy then becomes kinetic energy.



The worth of potential energy lies in its name—"potential." It does not become useful energy until transformed by some means into kinetic energy. The chemical energy in food, coal, uranium, gasoline, and other such materials is potential energy. For example, no useful work is done by chemicals in a storage battery until called upon to provide electrical energy.

Kinetic energy is energy in the form of motion, heat, sound, or light. It is the energy form used to operate machinery, run automobiles, power electrical appliances, and provide light and heat in buildings.Of course, it performs countless other tasks, too.

Kinetic energy can also be used to produce potential energy. Water pumped up from a lower elevation to a lake behind a dam is potential energy to be used at a later time. Using mechanical force to compress a spring is another example.

To a limited degree, kinetic energy can be stored. Heated water placed in an insulated storage tank or vacuum bottle is kinetic energy temporarily trapped.

Energy is also categorized in other ways. Energy resources in use today, for instance, are termed "developed resources" and are classified as either renewable or nonrenewable. Oil, coal, natural gas, and uranium are nonrenewable. Wood and hydro-electric energy are renewable.

Other resources such as oil shale, tar sands, thorium, and geothermal are called "undeveloped resources."

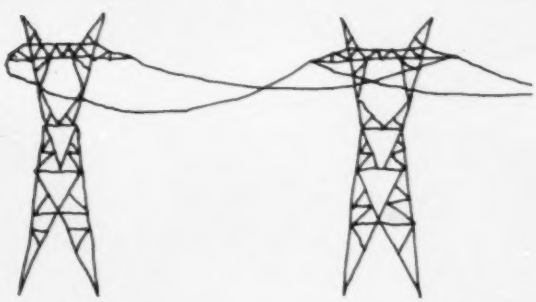
The U.S. Geological Survey lists fuel reserves of nonrenewable resources as identified recoverable, identified submarginal, undiscovered recoverable, and undiscovered submarginal. Identified recoverable is the energy most used now. And predictions of the short-term energy supply are made on the basis of identified recoverable reserves.

The end uses of all energy forms are also pinpointed. One agency has broken U.S. energy consumption down to four major categories: residential, commercial, industrial, and transportational. Then, each specific end use is identified, such as for space heating, water heating, cooking, and other uses. It should be noted that

space heating in the residential and commercial sectors, process steam and direct heat in the industrial category, and fuel in the transportational part accounted for more than 70 percent of the total national energy consumption in 1968.

Energy for consumer use is, in a way, in a class of its own. Since it is sold for consumer use, commercial energy must be in a form that can be easily and economically converted to meet consumer needs. Ease of transporation is an added consideration. Electrical and chemical energy are the types mainly meeting such requirements at this time.

Electric energy is produced by turbine-generation at power plants. But either chemical energy, nuclear power, or hydro-energy is required to spin the turbine-generators. Electric energy is then transported through conducting wires to homes, businesses, and industrial plants where electricity is utilized.



The primary fuels, containing chemical energy, are easily moved via ships, trucks, and pipelines for consumer use. The chemical energy then benefits consumers when primary fuels are converted to heat by combustion.

Approximately four percent of this nation's usable energy comes from hydroelectric generation, and less than two percent is nuclear generated. The remainder, about 94 percent, is attained with fossil fuels.

The Laws of Energy

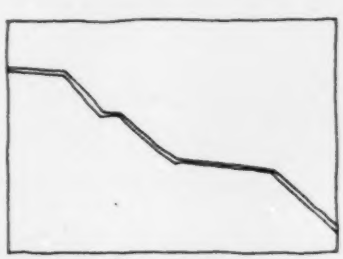
"Energy can neither be created nor destroyed" is the First Law of Thermodynamics. It can be changed from one form to another, but there will always be the same amount of total energy in the universe. Only the quantity of a particular form of energy is changed—not the total amount.

The Second Law of Thermodynamics states that "in any conversion of energy from one form to another, some energy becomes unavailable for further use." When a conversion occurs, some energy changes to heat, not all of which can be captured and returned to its usable state. The unusable heat energy is dissipated and gradually warms up the earth and universe. Energy loss is heightened with the more conversions made between the primary energy and its final use.

The Use of Energy

At the present rate of use, a baby born today will consume during its lifetime about 175 tons of coal, 2,000 barrels of oil, and 7.5 million cubic feet of natural gas. For a more vivid picture, one should consider that the average American uses the energy from 13.6 pounds of coal each day.

As already mentioned, the importance of energy in everyday life is too astronomical to be measured. Energy has made this country what it is today. It is a fact that the more energy wisely consumed, the higher the standard of living is apt to be. In the same light, the standard of living could be lowered as usable energy becomes less available.



Reserves

It is important to know how much energy is being used and by whom, especially if this country intends to set up a national energy policy. Also important along these lines is a need for information on nationwide reserves of the various energy resources. The extent of U.S. reserves of gas, oil, coal, uranium, and other fuels must be established. And what sectors of the economy use how much of each should be noted so a position to manage these remaining reserves can be established.

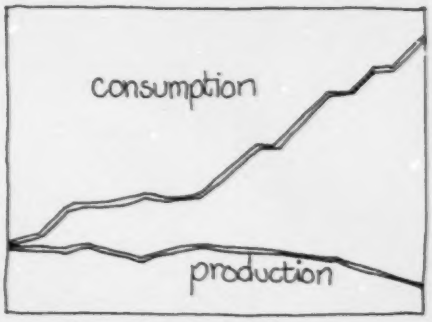
Predictions indicate that at the present rate of consumption, domestic supplies of natural gas and oil will be exhausted in a few decades. Using these reserves wisely is an important factor in shaping the national energy policy. The substitution of electricity generated by coal or uranium has already begun and undoubtedly will accelerate in the future, thus relating the need for the construction of more electric generating plants.

To help lay a foundation for the national energy policy, the federal government has sponsored several energy studies. But perhaps the majority of facts and figures quoted in energy discussions come from two other reports: *The Stanford Report*, made by the Stanford Research Institute; and a report entitled *The U.S. Energy Problem*, conducted by the Inter-Technology Corporation.

If this country is to achieve a goal of energy self-sufficiency, it must turn increasingly to electricity generated by coal and uranium. Virtually all uses of energy, currently consuming vast amounts of gas and oil, could use electricity as the primary source. In fact, drastic changes must be made in the energy field if this country plans to have enough energy to go around in the years to come.

The Shortages of Energy

The energy problem stems mainly from a shortage of oil and gas; a shortage off-shooting from several roots.



The roots of the current problem lie in the gap between comsumption and domestic energy production. Consumption grew virtually unchecked while domestic production of fuels has actually been stable since 1970. A major reason that energy consumption has grown so rapidly is that until 1974, it was a bargain compared to most other items. The price of energy, relative to the prices of other goods and services, actually declined during the 1960's. But there were other reasons on the consumption side:

A. Rate structure for natural gas and electricity promoted more consumption by offering large-volume users a significantly lower price per Btu (British Thermal Unit) than small users.

B. People are using more energy-consuming goods such as autos, air conditioners, home appliances, electric heating systems, color televisions, and petrochemical products (such as plastics, which require large amounts of energy in their manufacture and are themselves based on petroleum).

C. Construction of the interstate highway system brought a rapid increase in intercity, high-speed auto travel.

D. There has been a shift in freight from rail to truck and air transportation. Public expenditures for road and airport construction, plus military development of aircraft later used for freight and passenger

travel, were among the factors that caused this change.

E. Passenger air fares dropped in comparison with bus and rail fares, stimulating air traffic. While air fares increased eight percent between 1950 and 1970, bus and rail fares increased 90 and 47 percent respectively.

F. Investment tax incentives and steadily rising wage rates encouraged industry to expand with energy-intensive capital equipment.

G. The growth in suburbia has resulted in the soaring use of gasoline for commuting and the use of other energy for the single-family homes that were built.

At the same time, federal government policies worked to curb growth in energy production:

A. The foreign tax credit, which permits oil companies to subtract the payments to host governments from their U.S. income taxes, became a greater incentive to oil production abroad—rather than at home—during the 1950's and 1960's. Ironically, while the import quota system was trying to boost domestic oil production, the foreign tax credit was effectively stimulating oil production abroad by U.S. oil companies.

B. Federal Power Commission (FPC) regulation of natural gas prices and reductions in oil and gas depletion allowances in 1969 were also viewed by industry and others as a deterrent to development.

C. Price controls imposed in 1971 on fuels (as well as on other goods and services) distorted normal marketplace actions.

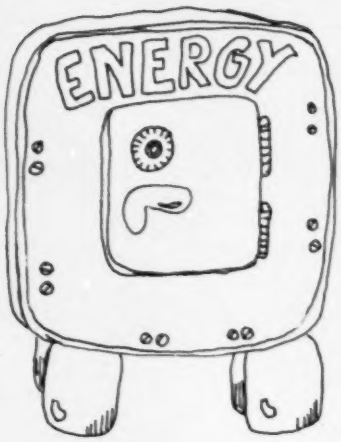
D. In 1969, offshore oil and gas lease sales were virtually halted for a year and a half.

E. Implementation of the Coal Mine Health and Safety Act of 1969 resulted in lower productivity in underground coal mines.

F. The National Environmental Policy Act of 1969 required detailed environmental and social impact assessments of major federal projects. This caused delays in the Trans-Alaska Pipeline, offshore lease sales, and nuclear power plants.

G. The Clean Air Act of 1970 caused industrial and power plant operations to turn from coal to natural gas and oil for meeting sulfur oxide standards. The same standards caused automobile manufacturers to build cars with reduced fuel economy to meet emission requirements.

Most of the previously noted policies were made because of desirable social purposes: environmental quality or economic well-being. Without them, domestic energy production might have grown at the same unchecked rate of consumption. Yet, such uncontrolled production of energy would have hastened environmental degradation and might have strained efforts to control inflation. As seen in hindsight, the trouble was not that economic controls and environmental laws were created, but that there was a failure to assess the impact that these policies would have on energy production and cost. Also, parallel policies to curb consumption and to spur the search for new, clean sources of energy were not developed.



The growing gap has occurred because a balanced energy budget was not a high-priority item in government until very recently. And actions to conserve energy were contrary to traditional thinking. But now, with energy resources in jeopardy, energy conservation is in the limelight. Everyone is urged to use energy wisely, so there will be enough for the future.

The Future of Energy

Man has been consuming natural resources at a drastic rate. Until recently, these resources have been inexpensive and abundant—factors that have caused energy to be consumed with little or no thought given to efficient use.

The situation has now changed to one of scarcity and higher prices. Known oil and natural gas reserves are already in danger of exhaustion, and coal, although scentists say there may be enough to last for about three centuries, presents air pollution and other environmental problems.

A shift of the U.S. energy base to make the greatest use of what is in greatest supply—uranium and coal—must come about. Technology must be improved and costs reduced, so coal and uranium can be utilized as efficiently as possible, which probably means for generating electricity. Also, a harder look at alternatives for producing energy is in order.

Opinions differ, but according to Lawrence Rocks and Richard P. Runyon in *The Energy Crisis*, the probable lifespans of energy sources in the United States are estimated as follows:

Natural Gas—40 years at the 1970 consumption rate; less than 30 years at the present growth rate.

Oil—20 years at the 1970 consumption rate; less than 15 years at the present growth rate.

Coal—200 to 300 years if used to produce synthetic oil and gas at the current demand.

I. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. Ask the students to look for ways electricity is used in their homes. Compile a list on the chalkboard and discuss the various uses of electric energy in the home.

2. Involve the class in a spelling bee that uses energy-related words: potential, kinetic, conservation, kilowatt, etc.

3. Ask the local utility to help the class find out which industries and plants are the largest energy users in the community. In what ways do these energy users benefit the community?

4. List some occupations in the community and determine how a shutdown in electrical consumption would affect each job.

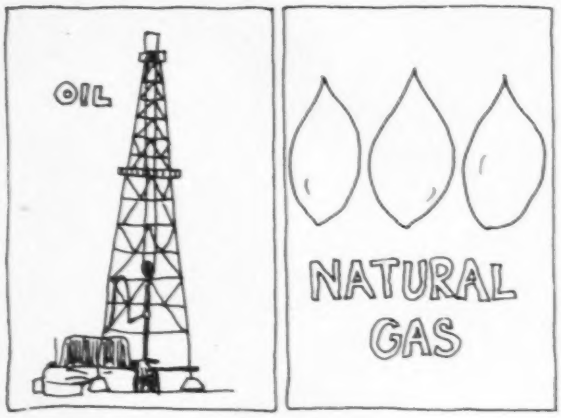
5. Have students put up energy conservation displays around the school. Sponsor a poster contest for the best energy-related entry.

6. Have the students compare the life style of an underdeveloped society with their own. Consideration should be given to the amount of energy consumption.

7. Discuss how an interruption of U.S. oil imports would affect one's personal life.

II. FACTS ABOUT OIL AND NATURAL GAS

Both fossil fuels, crude oil and natural gas are often found simultaneously in structural traps within the earth. Usually, such traps contain sand, and the oil and gas are positioned in tiny spaces between the grains of sand. But in some reservoirs the gas is dissolved in the oil. Others have the gas deposit over the oil. Gas pockets, too, are sometimes alone, without adjacent oil.



Oil and natural gas are used mainly in American homes and commercial buildings for space heating and water heating, with gas also being used extensively for cooking. According to 1970 figures, the 63.4 million occupied U.S. dwellings were heated as follows:

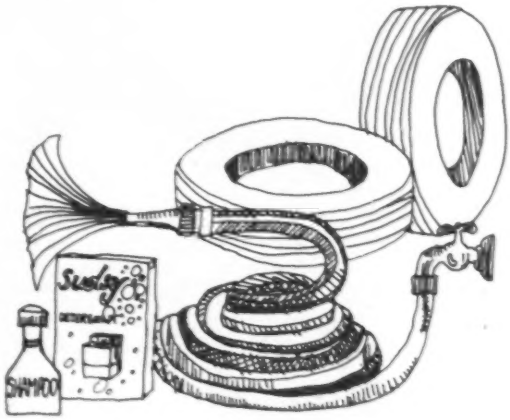
Natural Gas	55%
Oil	19%
Electricity	8%
Kerosene	7%
Bottled Gas	6%
Other (coal, coke, or wood)	5%

These percentages have undoubtedly changed and will continue to change as gas and oil become less available. In fact, home builders in some areas have already switched to electric heating as the only method available.

Natural gas and oil, of course, are also widely used in industry. The industrial use of oil and gas, like commercial and residential, has relied too much on these two dwindling resources. Of the total U.S. energy consumption about 31 percent is drawn from natural gas, and oil accounts for 45 percent, both in very short supply now.

Oil

Crude oil (petroleum) is one of the world's most valuable energy sources. It consists of a hydrocarbon mixture or compounds composed of carbon and hydrogen. The most familiar processed forms of petroleum are gasoline, kerosene, diesel fuel, heating oil, motor oil, and lubricants. Petroleum derivatives are also used for manufacturing thousands of other useful products, including detergents, fertilizers, drugs, cosmetics, plastics, road-building materials, and synthetic fibers and rubber.



It was thought at one time that there was a plentiful supply of oil in this country. (The same is true with natural gas.) But as it has turned out, there is not nearly as much oil reserved in the U.S. as previously predicted. The petroleum industry's estimates of proven economical U.S. oil reserves, as reported by the U.S. Geological Survey, run at 36.3 billion barrels of oil. (A barrel equals 42 gallons.) This estimated oil reserve is about the same as seven years production at the 1973 consumption rate.

Estimates of total recoverable resources cover a wide range. Future supplies are difficult to predict, partly because all forecasting must rely on results of past oil and gas exploration. Since very large areas are still unexplored and because techniques are constantly being improved, previous explorations are an unreliable base.

According to some theories, there are from 165 to 550 billion barrels of ultimate producible oil (by present technology) in the United States. In 1974 the U.S. was consuming about 20 million barrels per day, or approximately seven billion barrels per year. It must be noted, however, that present recovery techniques are only 30 percent efficient. In other words, for every gallon of oil pumped out of a well, about two gallons are left behind.

In a nutshell, most of the easily recoverable domestic reserves in this country have been consumed. The remaining supplies will be more difficult and costly to recover. That is why, in recent years, the U.S. has begun to import more and more of its oil.

When a nation cannot meet demands for oil through domestic resources, it must import. And the United States is a prime example. Oil production in the U.S. has declined since 1971. Therefore, a sharp dependency on imports has occurred. The Federal Energy Administration (FEA) predicts that up to 50 percent of domestic oil needs will rely on foreign sources by 1985 if present policies and patterns of demand continue.

Oil can be pumped more easily and cheaply in the Middle East than anywhere else in the world. The Middle East nations own the oil reserves necessary to support expected world-wide growth for the next decade. And until the Arab embargo, government and industry planners counted on oil imports from the Middle East to provide the bulk of growth in U.S. energy consumption.

The United States has to import oil to meet energy requirements. Even during the embargo, the U.S. continued to import more than five million barrels of oil per day, and if peace is maintained in the area, this country will probably import even more oil in the future. In fact, there has recently been a few days when oil imports exceeded domestic production.

Greater care and selectivity are needed in planning oil imports for the future. If the U.S. continues to import oil, despite the implications for international relations and the economic costs, measures are needed to lessen the impact of a possible embargo in the future. Central to any such program would be the establishment of some form of oil stockpile.

If oil could be imported in pre-war quantities at $10 per barrel, the cost would exceed $20 billion per year, with nearly $4 billion more per year for each additional million barrels per day. The high price of imported oil alone gives great impetus to efforts toward saving energy and finding alternative sources. Yet, the prospects in the next few years for reliable supplies at delivered prices much lower than $8 per

barrel look dim. The oil available for expanded production in the near term lies primarily in Saudi Arabia and Iran and possibly Iraq. The production of other nations has apparently peaked out for technical, economic, or political reasons.

Decreasing production does not portend well for the United States or any other oil importing nation. Unless a mammoth new discovery is made somewhere in the world in the next few years, or unless the smaller exporters resume growth in production, all the importing nations will be dependent on the growth in oil production of very few countries.

Natural Gas

According to some estimates, there are approximately 266 trillion cubic feet of natural gas on reserve in this country or close to 13 years production.

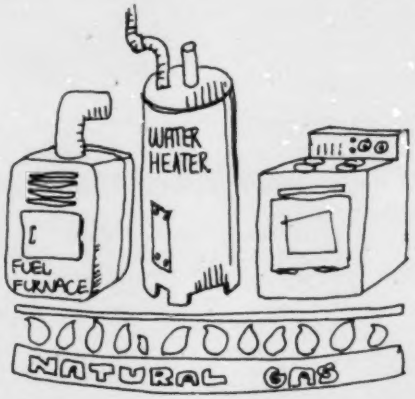
Domestic natural gas reserves, like those of petroleum, are being depleted rapidly, and few new major fields are being developed. Moreover, artificial restraints on the price of natural gas encourage its use in grossly unsuitable applications, such as boiler fuel for industry and utilities. The importation of natural gas requires that the gas be liquified for shipment and storage, a costly process reflected in much higher prices to the consumer. Thus natural gas, which should be conserved essentially for chemical raw material and light industrial use, is in serious jeopardy as a contributor to the national energy budget.

Natural gas was discovered by accident in 1821 at Fredonia, New York. It was little more than a tourist attraction for many years. But when larger supplies were discovered in a drilling operation for oil, natural gas was recognized as a valuable fuel resource.

Methane, the simplest compound of the hydrocarbon family, is the major component of natural gas. Other components in smaller proportions include ethane, propane, butane, and other complex hydrocarbons.

Many natural gases can be used directly from the well without treatment. But some must be processed to remove undesirable constituents such as carbon dioxide, hydrogen sulfide, and other sulfur components.

Methane is used to produce hydrogen, methanol, carbon tetrachloride, and many other chemicals. A raw material, butane is used for fabricating synthetic rubber.



In homes, natural gas can fuel furnaces, water heaters, and ranges. It supplies heat in industry for melting metals and glass, producing lime and cement, and for other operations requiring extreme heat.

There have been warnings about eventual natural gas shortages since the 1940's. These warnings have been issued by an array of government, industrial, and financial investigators. But the situation has been somewhat ignored because of optimistic claims. Forecasts of natural gas reserves have also lacked consistency because of competing research methods.

II. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. Collect newspaper and magazine articles on the energy situation. Use them to discover and graph trends, to make bulletin board displays, or to make a collage or mobile in an art project.

2. Instruct each student to complete the "Which 3?" game, available through power distributors and TVA. Then have a class discussion about why the various selections in the game were made.

3. Have the class name as many uses as possible (other than for fuel) for oil and natural gas.

4. Study the ways people have been motivated to use more energy in the past. Discuss the possibility of reversing the trend from promotion to the reduction of energy consumption.

5. Have the students write a paper about what each considers the most pressing energy problem today and why.

III. FACTS ABOUT COAL AND HYDROPOWER

Hydropower and coal are mainly used by utilities to generate electricity. When water force is used to turn giant turbines that generate electricity, it is termed hydroelectric generation. Coal is burned to boil water, which creates steam, and the steam then spins the turbines to generate electricity.

Coal

Until World War I, coal in the United States had almost no competition as the major source of energy. But then petroleum became an important energy source, and hydropower and natural gas surfaced in the 1930's as prime energy suppliers. And since then, coal has not been used as an energy source as much as gas and oil, both cleaner and easier to distribute.

Although coal is this nation's most prominent fossil fuel, it presents many drawbacks in regard to use. Stacked upon the other problems associated with coal is the current shortage of railroad equipment needed to transport it.

Other disadvantages include an undesirable sulfur content that lowers iron and steel quality. And too much sulfur in soil prohibits vegetation growth. Coal also contributes to the formation of boiler deposits, corrosion, and air pollution. Another detrimental factor is the pollution of mine water and nearby streams by sulfuric acid in mining areas.

The sulfur content in domestic coal varies from 0.2 to 1.0 percent in the Rocky Mountains and Northern Great Plains. But in the Appalachian and Interior coal basins, sulfur content can be as high as seven percent. Restrictions imposed by the Clean Air Act of 1970 virtually prohibit the use of high-sulfur coal by electric utilities because of resulting air pollution.

The mining of coal is also clouded with questions and problems, especially strip mining.

Having both advantages and disadvantages, strip mining is a controversial form of mining. In terms of human lives, it is by far the safest method of getting coal. It generally makes more complete use of the coal resources available and is not as expensive as other mining methods. And in some areas, strip mining creates otherwise impractical industry. On the other hand, it scars the landscape and may open the way to erosion and stream pollution. Private landowners and ecologists want to see the land reclaimed; however, there are concerns about the cost of land reclamation and its effect on coal prices.

Many utilities are being forced to shift from gas and oil to coal in spite of the difficulties and high costs. Some utilities have had the foresight to locate generating plants near coal mines, and some have acquired their own mines.

Coal production still lags although demand is rapidly increasing. Production

barriers include technical problems, uncertainties about labor and materials, and environmental roadblocks.

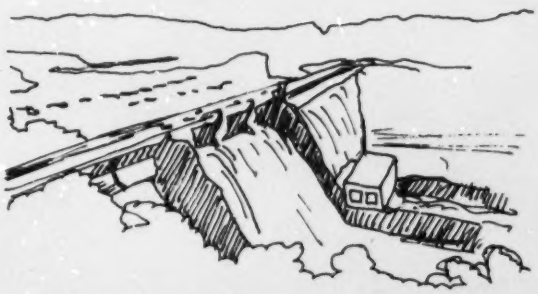
As already noted, electric utilities use most of the coal that is mined today, an amount six times greater annually than coal production 50 years ago. Coal consumption for generating electricity in 1974 was two-thirds of today's yearly production.

The steel industry is this country's second largest coal consumer, requiring about three-fourths of a ton for each ton of steel made. In this manufacturing process, coal is converted to coke and used in blast furnaces to melt iron ore.

Hydropower

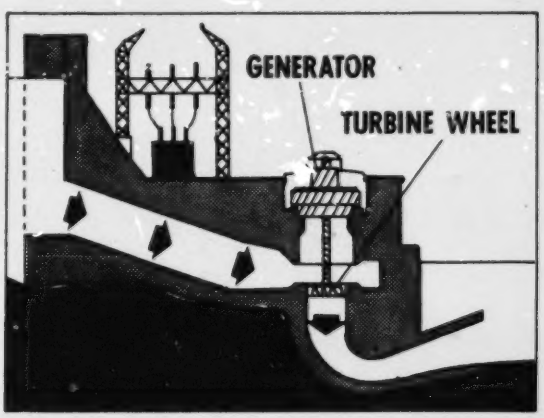
The amount of electricity that can be produced via hydropower varies from year to year, depending on the rainfall. But it is a renewable energy source.

The installed hydroelectric capacity of the U.S. is 53,404 megawatts (53,404 million watts) from which 266 billion kilowatthours were generated in 1974 (16 percent of the total electricity generated).



Most of the hydroelectric capacity is derived from hydroturbines located at dams. A small portion comes from pumped storage, which uses off-peak electricity to operate the turbines as pumps and reverse water flow into large storage lakes. The stored lake water is released to generate electricity needed in times of peak demand.

Hydropower is the least expensive way to generate electricity. That's why areas, such as the Pacific northwest where there is a considerable amount of suitable water, have lower power rates.



It has been suggested that dams be built on all streams and rivers so more cheap hydroelectric energy will be available. But not all waterways are suitable for dams. For instance, there are no dams on the Mississippi River. Its banks are not high enough, and a dam

would cause extensive flooding. Watersheds must be able to provide a large water storage area and the water level necessary to turn hydroelectric generators. In short, sites suitable for dams have already been developed. There are none left.

III. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. List some of the obstacles that stand in the way of using more coal for the generation of electricity.

2. What are the major pollutants produced by burning coal?

3. Discuss the advantages and disadvantages of both deep coal mining and surface mining. Cover such factors as safety, cost, land use, initial capital investment, stream pollution and land reclamation.

4. State some of the physical conditions required at a river site to make it feasible to build a hydro-generating plant. What are some of the objections to building new hydro plants?

5. Explain what is meant by pumped-storage hydro-generation. What are its advantages? Disadvantages?

IV. FACTS ABOUT NUCLEAR ENERGY

Uranium

Uranium is the most important source of nuclear energy. Although it costs more to mine, refine, isolate, and protect uranium and other radioactive energy sources, the potential energy output is quite large. For example, a pound of enriched uranium 235 is about the size of a golf ball, yet it has the same energy potential as three million pounds of coal.

In its natural state, uranium consists of approximately 0.7 percent U235, the isotope readily fissionable in conventional reactors. The remainder is mostly U238, an isotope that is not in a fissionable form. But U238 can be converted into a fissionable material.

Natural uranium is not pure enough for a conventional controlled chain reaction. In a process known as enrichment, natural uranium is gasified, and the readily fissionable U235 is forced into a higher concentration with U238 than normally occurs. This process raises the U235 content from 0.7 percent to about three percent of volume. In another process, fissionable plutonium (PU239) is created by bombarding U238 with neutrons under proper temperature and pressure conditions.

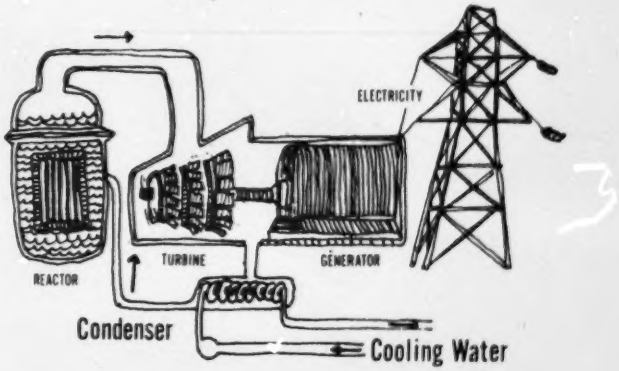
Some 200 tons of uranium are required annually as enrichment plant input to fuel a 1,000 megawatt light water nuclear generator operating at 80 percent load factor.

The Nuclear Regulatory Commission (NRC) currently controls enrichment at three facilities: Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. These facilities are rapidly reaching their capacity point. Plans for additional enrichment sites must be initiated soon to prevent a bottleneck in supply of enriched nuclear fuel.

Uranium demand will continue to climb for several years. However, the new Clinch River breeder reactor near Knoxville is expected to reverse the trend sometime between 1985 and 2000. Known economical domestic reserves can supply expected needs for natural uranium until the early 1980's. Domestic recoverable, hypothetical reserves could extend the supply into the 1990's.

Since utilities are reluctant to commit themselves to long-range contracts, the rate of uranium exploration has been relatively slow. High interest rates and long-term payouts are risks that discourage some miners and producers who might otherwise be interested in the commercial potential of uranium exploration.

Nuclear Power Production



Anticipating that domestic supplies will fall below needs, the NRC has proposed that import controls on uranium be relaxed. But such action would not contribute to this country's energy self-sufficiency, and the proposal may be rejected for that reason. If construction of nuclear generating plants advances at the most optimistic rate, annual uranium production must quadruple by 1985. Ten times the total past 25 years' production will be required in the next 25 years.

Uranium exploration and production must undergo major expansion to meet such energy needs.

There is also a need to accelerate the development and commercial operation of the fast breeder reactor before supplies of economical fissionable uranium are exhausted. The National Academy of Sciences has said, "Failure to make this transition would constitute one of the major disasters in human history."

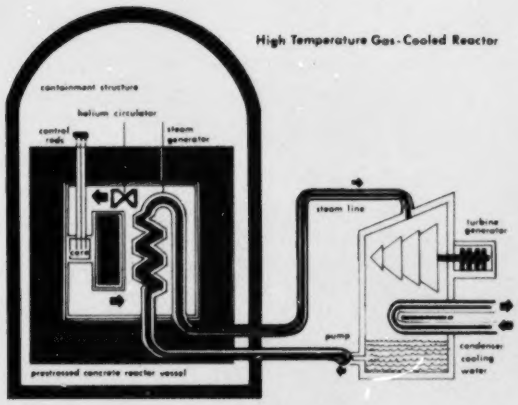
Nuclear Fuel Use

Electric power generation is the conversion of energy from one form into another. In 1974, electricity accounted for 25 percent of this country's total energy consumption. The types of electric generation plants in use are: fossil-fueled steam, nuclear, gas turbine, conventional hydro, pumped storage hydro, and combined cycle.

Because of varied problems and the shortages of fossil fuel, there has been a shift in the last 10 years to nuclear generation. Today, nuclear plants generate about seven percent of the nation's electric energy. The Energy Research Development Administration (ERDA) estimates that nuclear power will furnish approximately 16 percent of the total U.S. electric capacity by 1980.

Nuclear Fission

The most common types of nuclear generation in use today include the boiling water reactor (BWR), the pressurized water reactor (PWR), and the high temperature gas-cooled reactor (HTGR). These reactors are used in the process called nuclear fission.



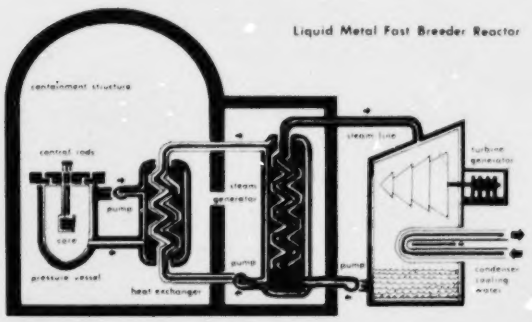
The nucleus is essentially the heart of any atom. It is the part of an atom that contains positively charged protons and uncharged neutrons. When the nucleus of an atomically heavy material, such as uranium, plutonium, or thorium, is hit by a neutron, it splits, releasing additional neutrons and energy in heat form. In the splitting reaction, the nucleus of the atom first bombarded releases high-energy neutrons that fly off to split other atoms, repeating the process. This operation is nuclear fission. In a controlled situation the heat created by splitting nuclei is used to produce steam for turning turbines to generate electricity.

Breeder Reactor

When energy in current resources is consumed, it is used up and cannot be renewed. This is also true with energy used in conventional nuclear reactors. And too, there is waste in today's methods. For instance, conventional reactors can use less than one percent of the energy in uranium ore. So scientists have sought and discovered a better, more efficient way to use nuclear power in the future.

The breeder reactor will produce about five pounds of usable fuel for every four pounds it consumes. While using plutonium-239 in its operation, it creates a fuel supply by converting uranium-238 to plutonium-239. The plutonium-239 yielded in the procedure can be recovered chemically.

There are three types of breeder reactors now being studied. In the United States the Liquid Metal Fast Breeder Reactor (LMFBR) is primarily emphasized. Being cooled with liquid sodium metal, it does not need an agent to moderate or slow down the neutrons, making it a fast "breeder." It is expected to "breed" twice as much fuel as it uses in some 30 years.



The Gas-Cooled Breeder Reactor (GCBR) has the possibility of doubling its own fuel supply in approximately 10 years. Another system, the Light Water Breeder Reactor (LWBR) being developed, does not have the efficiency of the other units, but supposedly could be in operation sooner and at lower costs.

Fusion

When two lighter elements are fused together by extreme heat and pressure to form a new heavier element, a great amount of energy is produced. This is the basis of nuclear fusion.

The elements man has used for nuclear fusion are deuterium (heavy hydrogen) and a radioisotope of hydrogen called tritium. But when these two elements are meshed together for fusion purposes, the reaction is chaotic and is exceedingly difficult to control for a sustained time period. The major handicap is governing the high temperature required for the reaction—more than 100,000,000 degrees F. No known material can withstand that much heat. But research continues because of the attractive assets nuclear fusion offers.

Deuterium is found abundantly in ordinary sea water, from which it can be easily extracted. And the energy in a pound of heavy hydrogen equals the heat produced by burning 5,000 tons of coal. Inherent safety with no possibility of nuclear runaway is another advantage to controlled fusion. Waste disposal problems are also eliminated because there are no radioactive output products. Also, the possibility of converting fusion power directly into electricity, bypassing such operations as steam generation, makes nuclear fusion very attractive, indeed.

Many methods are presently being researched so nuclear fusion can be commercially practical as soon as possible. But even the most optimistic forecasters don't expect it before the year 2000.

Thorium

Little demand exists for thorium at this time, but it has vast potential as a future nuclear fuel.

The largest known thorium source is situated in the Conway Granite of New Hampshire. It is a deposit exposed over an area of 300 square miles and perhaps several miles deep. Although this deposit has only about two ounces of thorium per ton of rock, it still merits mining. The energy released from the thorium contained in just one cubic yard of this rock is equivalent to 300 tons of coal or 1,500 barrels of oil.

Due to the amount of domestic reserves, thorium-fueled reactors could become the most popular type of nuclear electric generator, according to some speculations.

IV. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. Discuss the principles of nuclear electrical generation and some of the safety features used.

2. There are two basic types of nuclear reactors now in use, the pressurized water reactor (PWR) and the boiling water reactor (BWR). Have the class research the two types and draw a simple schematic diagram of each.

3. Many in the electric utility business say that this country will be heavily dependent on coal and nuclear power for electricity generation. Do you agree? Why?

4. What will be the breeder reactor's major contribution to future nuclear generation?

5. How much radiation does a person receive in a year's time if he lives close to a nuclear plant? Compare this with:
   a. normal radiation from natural sources
   b. a jet plane trip from New York to San Francisco
   c. living at 5,000 feet altitude
   d. two X-rays of the bones per year

6. Discuss the various proposals for depositing nuclear waste materials.

7. Have a mock discussion of location hearings for a nuclear power plant. Choose representatives of transportation, labor, utility, industry, city and state government, environment-protection groups, etc., for the discussion.

V. FACTS ABOUT ENERGY USED FOR TRANSPORTATION

Gasoline

The United States has become wedded to the automobile. Although less than six percent of the world's population, Americans own 45 percent of the world's cars. There are about 100 million privately owned, registered passenger cars in this country. These cars consume more than 75 billion gallons of gasoline and travel over 1,000 billion miles each year.

But more energy goes into an automobile than readily meets the eye—more than just the gasoline used for fuel.

1. It takes an enormous amount of various energy forms to manufacture one automobile. This energy is the equivalent of 1,200 gallons of gasoline, or enough to run the car about 16,000 miles.

2. It requires energy to ship cars from the factory to showrooms, to display them in showrooms, to demonstrate the cars for potential buyers, and to make replacement parts.

3. It takes two gallons of gasoline to make every 10 gallons pumped into the car's tank.

4. It has been estimated that more than 21,000 square miles of U.S. land surface has been paved for streets, highways, and parking lots, mostly to accommodate automobiles.

5. It is said that one out of every six jobs in the U.S. is related to the automotive industry in some way.

Estimates vary, but most authorities agree that the average car gets about 12 to 13 miles per gallon on the road. A car's average gas mileage, however, has been dropping steadily in recent years. Compared with foreign cars driven in areas of the world where gasoline prices have been historically high, American automobiles are truly "gas guzzlers." But the current car trend is turning to smaller cars that get better gas mileage.

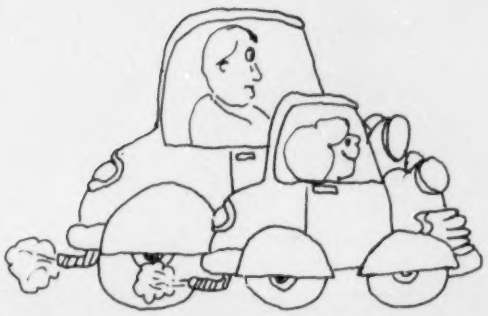
Individuals can help cut America's tremendous gasoline consumption. Most working Americans, more than 80 percent, drive to and from work in automobiles, and over half drive alone. It is easy to see, considering a car's average gas mileage, that anything automobile owners can do to reduce daily driving will save money and energy.

The potential for savings by organizing a 3- or 4-person car pool is impressive. For instance, driving 10 miles each day, round trip, for 260 days, equals 2,600 miles per year. By sharing this mileage with two other drivers, one would have to drive every third day, cutting individual annual driving by 1,733 miles and gas purchases by 133 gallons. At 55 cents per gallon, this would save each person $73 annually for gasoline alone. Each would also save on tires, servicing, repairs, and other expenses.

One study shows that 31.4 percent of all passenger car trips are for local errands—to the doctor, dentist, stores, etc.—which average 11 miles a round trip. With some foresight and planning, many small trips could be combined, saving a considerable amount on family gasoline purchases.

Until 1973, the price of gasoline was relatively low in this country. As a result most people, when buying a new car, didn't consider gas mileage as a factor in deciding what size car they would buy. But now with the cost of gasoline rising steadily, compact cars are gaining a larger share of the new car market. Consumers are becoming more conscious of gas mileage for good reason.

A medium-sized car weighing 3,500 pounds will get about 13 miles to a gallon. Assuming the car is driven 12,000 miles a year, it would use 923 gallons, which at 55 cents per gallon would cost $508. A compact car weighing about 2,000 pounds will get 25 miles per gallon and use 480 gallons in the same 12,000 miles at a cost of $264. The compact car would save $244 annually. But compact cars loaded down with air-conditioning, automatic transmission, power steering, and power brakes are not energy savers.



One study estimates that if the U.S. can eliminate all the large, high-horsepowered automobiles in the next 5 to 10 years, replacing them with economy-sized, energy-efficient vehicles, 1/2-bilion barrels of petroleum products could be saved annually. This represents about 20 percent of the present energy consumption by the transportation sector.

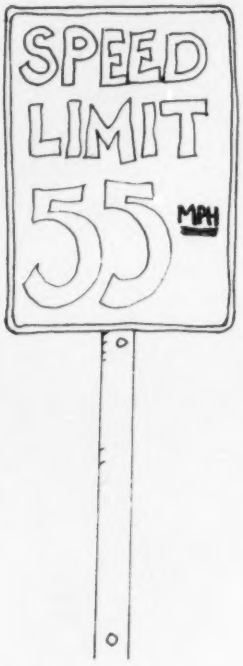
Personal driving habits make a marked difference in a car's fuel consumption. Proper maintenance will also help a car conserve gasoline, which saves the owner money.

1. Speed—Slower driving saves gasoline. That's mainly why the national speed limit was lowered to 55 miles per hour. A reduction in speed from 70 to 50 will drop gasoline use by 25 percent per mile.

2. Less "Sunday Afternoon" Driving—A 50-mile trip can use up to four gallons of gas, costing two dollars or more. And if the trip is just for sightseeing, it's simply a waste of energy and money.

3. "Jackrabbit" Starts and Stops—Drivers should never accelerate fast on takeoffs, especially when expecting to stop a block or two down the street. Such a habit is very wasteful.

4. Automobile Maintenance—Keeping a car tuned and adjusted will increase gasoline mileage. Properly inflated tires also help. Some say that using radial tires will give up to 10 percent better gas mileage.



Electricity

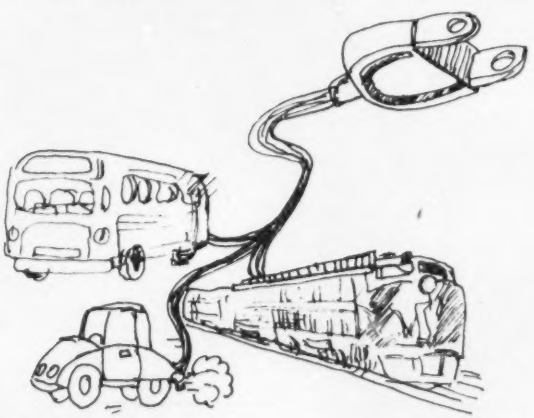
From an energy-efficiency standpoint, development of electrical transportation seems most in tune with the times.

Railroads—Electric trains, noted for their speed and efficiency in other parts of the world, should become a part of the American landscape. The electric locomotive is much more efficient than the diesel-electric, requiring less than half the energy resources to transport goods or people. Compared to the truck, an electric train requires only one-eighth the energy resources per ton-mile.

In the U.S. today, there are approximately 340,000 miles of track that could be used for electric trains. The technology and equipment for electrifying mainline railroads in this country are at hand. The difficulties, though, are mainly economic in nature.

Rapid Transit—Railroads of the future may mostly move freight. Movement of people will be by newer systems, some experts speculate. Some designs being suggested for mass transit systems involve traditional multipassenger cars traveling at speeds of 150-250 mph or higher. Others envision the use of individual or two-passenger units which would operate under the driver's control where desired, but would come onto an automatic guideway for high-speed travel.

All mass transit is not high speed, moving walkways, for example. Some engineers foresee future low-speed systems moving people in and around crowded places.

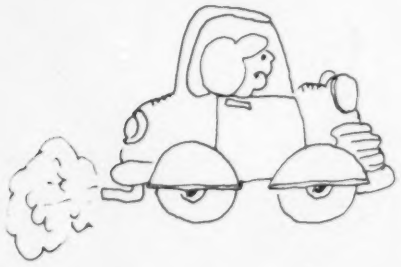


Industrial Uses—The most readily available market for electric transportation in this country today is for in-plant industrial use. About 30 percent of the fork-lift trucks in use in 1971 were electric.

Special Purpose Vehicles—Another market immediately open is for special purpose vehicles, such as small police cars, vehicles for warehouse use, leisure-time vehicles, and farm and agriculture vehicles, including garden tractors.

Electric Automobile—Major development of the electric car might be prompted because:

A. It is less polluting than internal-combustion engine cars. The pollution due to the electric automobile comes primarily from the electric power plant. There, the major offenders are the concentrated heat release (thermal pollution), the emission of particulates (primarily from coal-fired facilities), the emission of oxides of nitrogen and sulfur (coal-fired plants), and the problems relating to the disposal of radioactive material (nuclear plants). It should be noted that with electric vehicles, any pollution is at the central point of the generating plant and there it can be controlled.



B. The available supply of petroleum may be reduced significantly. The primary fuel for the electric car would probably be coal or uranium, at least for the next couple of decades. Petroleum resources are difficult to estimate, particularly because of the international character of the market It does seem reasonable, however, that the demand for petroleum and its decreasing availability may force the cost of gasoline to rise more rapidly than the cost of electricity. This would also encourage the development of the electric automobile.

C. The electric car might cost less. The ones on the market now sell for around $3,000. A big step forward for the electric vehicle would be a great breakthrough in battery technology. Improvements over the lead-acid battery are needed to increase the top speed and range of the electric car. Electric car use is presently restricted to on-site or in-city driving. The Japanese, though, are testing an improved version. It is said to have a top speed of 58 mph and a range of 150 miles between charges.

Also, compared to a d.c. motor system, the a.c. induction motor controlled by solid-state circuits gives the promise of higher efficiency and lower cost.

The Electric Vehicle Council believes the growth of a sound electric transportation system in this country, including railroads, rapid transit, work vehicles, and electric cars will substantially benefit the nation's quality of life.

Studies have shown it requires four times the energy to get a person back and forth to work by car than by bus. The following table puts into perspective the energy used for moving people and goods in intercity travel.

Transportation Mode	Btu Per Passenger Mile	Btu Per Ton Mile
Buses	1,090	-
Railroads	1,700*	680**
Automobiles	4,250	-
Airplanes	9,700	37,000
Trucks	-	2,340

*900 Btu per passenger mile for electric railway (input at generating station).

**320 Btu per ton mile for electric railway (input at the generating station).

About a quarter of the United States' energy is used for various modes of transportation: automobiles, trucks, buses, airplanes, railroads, farm vehicles, ships, and boats. And since the entire economy depends so heavily upon all forms of transportation, the rise in transportational energy consumption has been rapid. In the last 25 years the amount of energy used in transportation has increased by 84 percent. The trend shows no sign of leveling off at this time.

V. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. To conserve gasoline, pretend that a decision has been made to reduce the number of automobiles in this country. Have the class draft a set of priorities and regulations to accomplish this as fairly as possible for all citizens.

2. Have students do creative writing relative to gasoline rationing or curtailment. Example: "How would life in my family be affected if our gasoline supply were cut in half?" Then compute class totals or averages of "unnecessary mileage" before and after the conservation plan is implemented. Show comparisons on line or bar graphs.

3. If gas rationing were implemented, and we got only nine gallons per week per car, what would be the effect on the following:

    a. family vacation plans?

    b. car pools?

    c. mass transit systems?

    d. attendance at sports events?

    e. unemployment?

    f. sale of electric cars, bicycles, etc.?

    g. motel and hotel industry?

    h. other?

4. If electric locomotives are relatively more efficient than diesel locomotives, what has held back the electrification of railroad lines? What do you feel should be the trend toward electrification in the future?

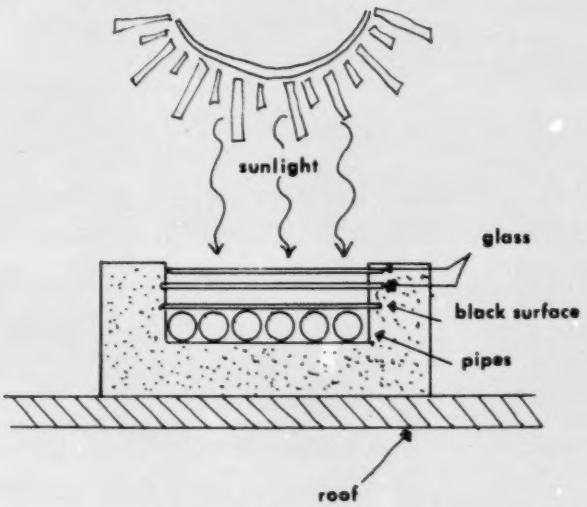
VI. FACTS ABOUT FUTURE ENERGY SOURCES

Solar

Except for a few hundred pounds of meteorites each year and some tidal energy, the only new resource currently reaching earth is solar energy. The total solar incident in earth's vicinity is enormous. The U.S. alone intercepts 700 times its 1970 energy consumption in one year.

Man used solar energy the first day he saw the sun. It gave him light and kept him warm. It is a free energy source, very large and potentially unlimited. But harnessing solar energy presents two major problems. Although the energy source itself is free for the taking, the means of increasing its use for man's benefit is expensive. Secondly, technology is lacking. There are problems of collection, concentration, and variables such as intermittancy (day and night), intensity (season and geography), and interruption (cloud cover). Such obstacles must be overcome before solar energy can be used efficiently.

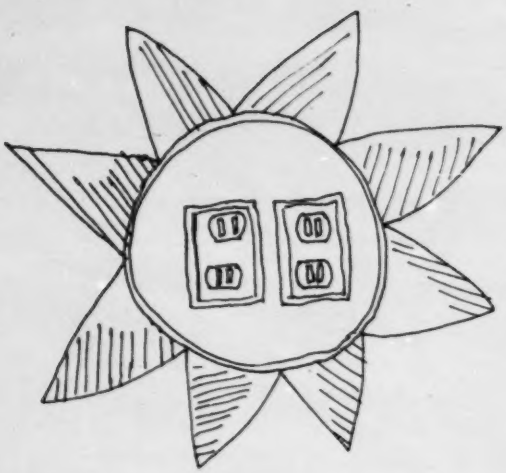
Solar energy, however, has been tried with reasonable success as a method of heating and cooling buildings and heating water. The most widely used system for gathering the sun's energy is a rooftop collector, which consists of a flat plate to absorb heat from the sun's rays. The energy absorbed by the plate is transferred to air or to a liquid, usually water, and then it is circulated to a location where it is stored or used. This procedure, as with other methods of solar use, needs to be improved. But a lack of standardization and capital investment has hindered many aspects of application.



Also showing promise is the production of "clean" renewable fuels, such as alcohol, methane, oils, and other carbon products by processing crops grown basically with solar energy. Or, these crops could be burned as a substitute for fossil fuels.

Photovoltaic Cells

Developed during the space program, photovoltaic cells can generate electricity directly from sunlight. They may be the ultimate solar power devices, but at present electricity from photovoltaic cells is much more expensive per kilowatthour than that generated by conventional modes. Japan and the United States plan terrestrial application of photovoltaic technology before 1980. But costs are reportedly hedging these efforts.



Magnetohydrodynamics (MHD)

MHD is a process of converting hot gases directly into electricity by passing them through super-conducting magnets. Eliminating the intermediate stage of steam generation, it improves efficiency.

For the MHD operation, gases would have to be heated to a temperature at least five times greater than achieved at a conventional fossil-fired steam generation plant. The burner, somewhat similar to a rocket engine, would burn the fuel to produce these extremely hot gases. These gases would be made conductive by the addition of small quantities of a metal alkali, such as ionized cesium or potassium.

As the gases move along the rocket-like generator, they pass through a strong magnetic field set up by the super-conducting magnets. This passage of hot conductive gases generates an electric current in electrodes within the magnetic field. This direct current (dc) is then transmitted to a circuit external to the generator. If it is to be used with conventional systems, direct current must be converted to alternating current (ac).

Electrical generation by magnetohydrodynamics still faces many technological hurdles, such as constructing the gigantic super-conducting magnet for use outside laboratory conditions and extending the practical life span of generators operating at such high temperatures.

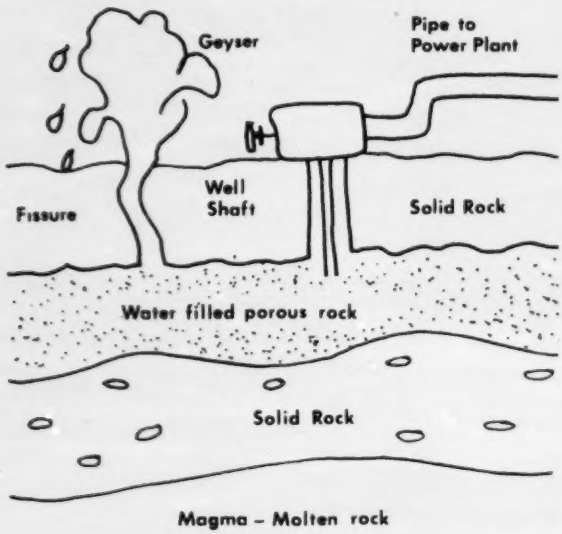
Geothermal

Geothermal energy is that extracted from the earth's natural heat. The earth's molten core is heated by the decay of radioactive materials, reaching a temperature greater than 1,000 degrees C. (1,832 degrees F.). Solar and lunar tides create friction forces within the earth. The motion of the continental crust also causes friction. This friction heat combines with the earth's radioactive heat.

Progressing from the earth's crust to its center, temperatures normally rise 30 degrees C. (54 degrees F.) per 1,000 meters. But certain geological conditions have united in some areas to form unusual "pockets" of pressure and heat. Such areas, called geothermal reservoirs, are usually found at shallow depths and in the vicinity of former volcanic activity.

Where underground water comes in contact with these pockets or reservoirs, hot water and steam are produced. Warm Springs, Georgia, and Yellowstone Park are examples of these areas. Three forms of energy are found in such reservoirs: dry steam, wet steam and hot water, and dry hot rock.

In the United States geothermal energy has been developed to drive generators at the Geysers in northern California, known for centuries because of eruptive activity. Another California site is in Imperial Valley, having geothermal pools of hot water and wet steam. Other "pockets" are in the eastern Sierras, Louisiana, and Texas. But while reservoirs in some parts of the world are relatively pure, those in America are high in dissolved salts and minerals that could present a pollution problem.



Oil Shale and Tar Sands

The oil shale of western American and Canadian tar sands hold another source of future energy.

Oil shale, a sedimentary formation, embodies kerogen, an organic substance that melts at about 500 degrees C. (932 degrees F.). Vapors released during the melting process are condensed and converted to shale oil, which can be refined into gasoline, oil, and other petro-products.

Most tar sands are in Canada. The sand particles are covered with a thin layer of bitumen (often called "tar"), which has a makeup similar to coal. Presently, the sands are surface mined and heated in water for bitumen removal. It is then desulfurized and refined into a burnable fuel.

Today's technology, the lack of water, environmental threats, and governmental restrictions preclude more than token production in the next 10 years.

Wind and Air Currents

People have known the force and value of winds for centuries. Sailboats and windmills are early examples of harnessing this kinetic energy.

Winds vary on a seasonal, monthly, daily, and hourly basis. They also change from place to place. This makes harnessing wind for a dependable source of power very difficult, and also, the factors causing winds are extremely complex and interwoven and often unpredictable.

Before the refining of the steam engine and advent of gasoline engines, 19th-century windmills produced a considerable amount of energy. Although other means replaced wind power as a major energy source, small windmills are still being used today in isolated areas to operate individual water pumps and small electric generators, usually charging a stack of storage batteries. But declining fossil fuel supplies have caused scientists to take a fresh look at wind and air currents as an energy source.

There have been attempts to generate electric power with wind. But lack of factual data on wind and technological limitations have proved them successful only as learning efforts.

Interest was recently revived by scientists and environmentalists. But mainly, the new efforts are being directed at modifying and improving wind generators for local and individual applications.

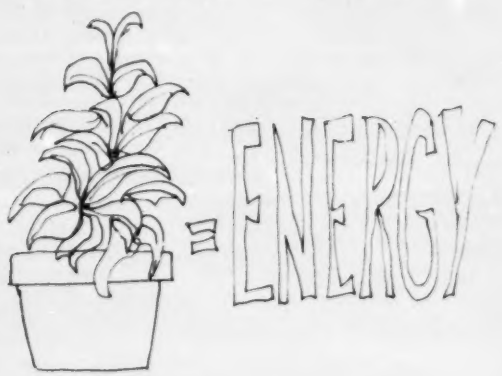
Tidal

Although most agree that it now has more disadvantages than advantages, tidal energy should be deemed a possibility for electrical generation in the future. But there are only a limited number of locations suitable for tidal generation.

Vegetation

Green plants are natural converters of solar energy. In the search for long-range energy sources, especially since 1950, much scientific study has been devoted to the massive production of energy fuels from green plants.

Because conversion loses efficiency even in a controlled process, producing fuel energy from plants poses a difficult problem. The photosynthesis process of converting the sun's energy into chemical form only utilizes about one percent of the original solar energy shed on the plant.



Of course, burning is another way to obtain energy from plants. It is felt by some authorities that the cost of wood as fuel, with proper use and management, could be competitive with fossil fuels. But detrimental environmental factors would come into play.

Algae, fast-growing, single-cell organisms, has possibilities, but now installation and harvesting costs make the unit price of this potential energy source prohibitive for fuel, though possibly proving feasible for food.

In a final area of experimenting with plants for fuel, carbohydrates, such as cereal grains, may be fermented and distilled to produce ethyl alcohol, a convenient and combustible compound.

Waste Materials

One of the main reasons waste material bids to be a major source of future energy is because something has to be done with it. In this country alone over two-billion tons of all organic solid wastes and more than a billion tons of all inorganic (mineral) wastes are accumulated each year. And just a very minute portion of this waste is recycled for energy, metals, and glass.

Organic wastes are end results of photosynthesis. They can be converted to fuels. But they are presently a burden and cost, relegated to land fills, dumps, lagoons, and other hiding places. The amount of waste in cities and high-density areas has doubled in the past 20 years. There are, however, opportunities for relief—possibly profit—by converting organic waste materials to fuel, fertilizer, and recycled usable goods.

One method, hydrogenation, yields a fuel oil with excellent heating qualities. The organic material is placed in a reaction vessel and heated to 380 degrees C. before carbon dioxide is added. In 20 minutes almost half of the material is transformed into oil, approaching capabilities of 15,000 Btu's per pound. (Normal fuel oil contains 20,000 Btu's per pound.) This synthetic oil is extremely low in sulfur, and part of it may be used to power the operation.

To produce heating values comparable with those derived from the hydrogenation process, pyrolysis makes fuel out of cattle manure, which is high in cellulose content. The cattle manure is heated to 900 degrees C. in a closed reaction chamber for six hours at normal atmospheric pressure. Gas, oil, and combustible solids are released by the process. Pyrolysis is presently being used at many places throughout the country.

A third and well-known means of changing organic waste to fuels is natural fermentation. This method employs anaerobic bacteria for converting waste to methane and carbon dioxide. (Nature used fermentation over a great time span to produce fossil fuels.) A good fertilizer with methane as a by-product can be produced by a variation of this natural process.

Fermentation, too, has its problems, the main one being collectability of waste. For example, Americans produced 880 million tons of household trash and garbage in 1971, but only 136 million tons could have been economically collected for processing into energy fuels.

VI. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. What economically feasible applications for solar cell use can you think of despite the high cost?

2. Have the class discuss the current uses of solar energy:

   - photosynthesis
   - solar cells
   - solar furnace
   - solar water heating

3. Have the students make a simple solar heat collector using a flat box lined with foam or another insulation. Then paint it black. Place a glass pane over the box and measure the rapid rise in temperature.

4. What are the main limitations in the harnessing of the sun's energy? What means are used to store this energy when the sun is not shining?

5. Have the students describe the limitations and advantages of geothermal sources of energy.

6. Have the students discuss wind power. List some of the limitations and advantages. How can this energy be stored during periods when the wind is not blowing?

7. Have the students compare fission and fusion reactors (concept only) for the production of electricity.

VII. FACTS ABOUT ELECTRIC POWER SOURCES IN THE TVA AREA

The electric power used in the Tennessee Valley is produced by falling water, by burning coal and oil, and by nuclear fission. The different types of generation making up the TVA power system are shown in chart (VII-1). Graph (VII-2) reflects the proposed forms of generation up to 1982.

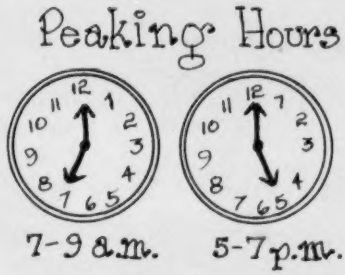
Hydroelectric Generation

Hydroelectric generation is electricity created by falling water. The force of falling water spins turbines or water wheels that are connected to generating units which in turn produce electricity.

1. Dams—About 17 percent of TVA's power is produced at hydroelectric plants located at dams along the Tennessee and Cumberland Rivers and their tributaries. The percentage of power produced by water varies from year to year depending on the amount of rainfall and when it occurs.

   TVA has 29 dams with 109 generating units, for a capacity of 3,195,930 kilowatts. TVA also obtains the electricity created at 12 Alcoa dams, generating a capacity of 423,715 kilowatts. Eight Corps of Engineers dams, having a generating capacity of 853,000 kilowatts, provide TVA with power, too. The total hydroelectric generating capacity available to TVA is 4,472,645 kilowatts.

   The hydroelectric generating units are used for normal power production as well as peaking. (Peaking power is the electricity required for only short periods of time when the most people are using the most power.) Peaking hours are usually between 7-9 a.m. and again from 5-7 p.m.



   For peaking purposes, it is fortunate that the TVA region is positioned in two time zones. When the people in the east have finished cooking breakfast and are leaving for work, people in the west are just waking up. And easterners are having their evening meal about the time westerners are arriving home from work.

   In regard to peaking, hydroelectric generation has another advantage. Hydroelectric units reach full output in minutes, whereas coal-fired plants require several hours to reach complete capacity.

   Most people think a dam for generating electricity can be built anywhere. It cannot. The river and surrounding countryside must have certain characteristics. One trait, for example, is high banks along the river. This is necessary to contain water that will rise behind the dam. Without high banks the river would spread out over countless miles, causing more problems than the dam would solve. So since all suitable sites have already been developed, no additional hydroelectric generation is planned along the rivers.

2. Pumped Storage—Water, however, can fall from a mountaintop rather than through a dam to generate electricity. This is the basis of the pumped storage system.

   Raccoon Mountain Pumped Storage Hydroelectric Plant is being constructed atop Raccoon Mountain, about six miles west of Chattanooga.

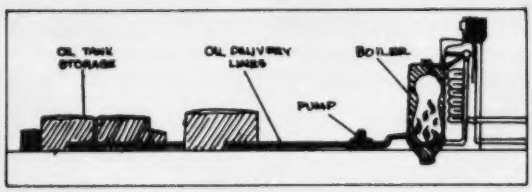
It will have four pump/generator units with an output capacity of 1,530,000 kilowatts. Scheduled for operation in 1978, this plant will be used to produce peaking and emergency power.

During periods of low power requirements, water from Nickajack Lake will be pumped approximately 1,000 feet up the mountain into a 528-acre storage lake. (Low power requirements occur at night and on weekends.) When emergency or peak power is needed, the water is allowed to flow from the mountaintop lake through the generators down to Nickajack Lake, thus producing electric power.

Oil Turbines

Fundamentally used for furnishing electricity during peak demand periods, some oil-fired turbine generating units exist within the TVA system. However, the main electrical generation at these sites is by steam-powered turbines, utilizing coal as the chief energy source.

At the Allen Steam Plant, there are 20 oil turbines with a total generating capacity of 620,000 kilowatts. There are eight oil turbines with a total generating output of 476,000 kilowatts at the Colbert Steam Plant. Another 10 oil turbines, totaling an output potential of 678,000 kilowatts, are being installed at the Johnsonville Steam Plant. Such turbines are also being set up at the Gallatin Steam Plant.

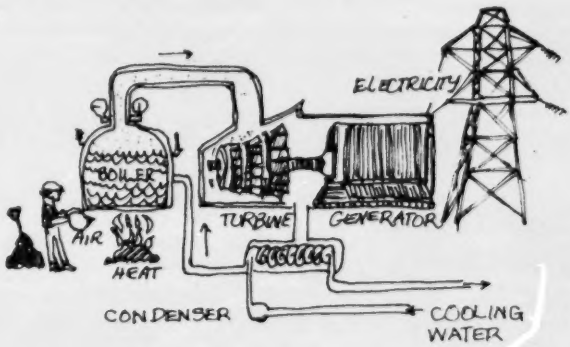


Oil turbines are expensive to operate. But they can be quickly constructed and running in comparison with steam plants. Oil turbines can also be put on the line in a few minutes, making them highly suitable for use during peak hours. However, oil turbines represent only a small percentage of TVA's total generating capacity. The high cost of oil makes it impossible to use them for anything but peaking.

Coal-fired Steam Plants

These units are the heart of the TVA power system. They produce approximately 75 percent of the system's power. Coal-fired steam plants have a total generating capacity of 17,749,585 kilowatts.

Hydroelectric generation long ago ceased to be sufficient to meet the region's needs. TVA, following its Congressional mandate of supplying the region's electricity, turned to coal-fired steam plants to increase its electrical generating capacity.



FOSSIL FUEL POWER PRODUCTION

TVA's first coal-fired steam plant, Watts Bar, was placed on line in 1945. Since then, 11 more have been added, the last one being completed in 1973. Presently, TVA has no plans for additional coal-fired steam plants. Scheduled additions to the system will be nuclear.

Nuclear Plants

As fossil fuels increase in price and decrease in availability, nuclear power becomes the logical alternative for generating electricity.

In 1967, TVA began construction of its first nuclear steam plant, Brown's Ferry, near Athens, Alabama. When all three units are in full operation, Brown's Ferry, the world's largest nuclear generating plant, will have an output capacity of 3,456,000 kilowatts. All 29 TVA dams combined cannot produce as much electricity.

TVA has six other nuclear plants either under construction or in the planning stage. If building remains on schedule, nuclear plants will double TVA's generating capacity by 1984. The system's capacity was 24 million kilowatts in November, 1974. But by 1984, expected generating strength will be 48 million kilowatts, of which 21 million is to be nuclear fueled.

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VII. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. Electric power in the TVA area is produced by falling water, by burning coal and oil, and by nuclear fission. Approximately what percentage of the total is produced by each? How will these percentages shift in the next ten years? Discuss reasons for the changes.

2. Arrange for the class to visit the nearest TVA hydro-generating plant.

3. Most TVA dams are multipurpose. Besides generating electricity, what other benefits do they provide?

4. TVA has interconnections with surrounding utilities for the exchange of electric power. List three benefits derived from this arrangement.

5. The TVA power area covers two time zones. Why is this advantageous in planning and operating the power system?

6. List some of the advantages and disadvantages of generating electricity at nuclear plants, dams, coal-fired plants, oil-fired plants.

7. Through the electric system that serves your school, arrange for a speaker to come to your school and discuss TVA's power program.

VIII. FACTS ABOUT ENERGY CONSERVATION

The Wise Use of Residential Energy

There are two primary causes for energy waste in homes: 1. Excessive heat loss and heat gain in the structure itself. 2. Wasteful living habits from days of inexpensive energy.

The majority of the homes in this country were built when energy was inexpensive and before air conditioning was in widespread use. Little if any insulation was installed when the houses were built. And many houses were built with large, single-glass windows. Doors and windows were generally loose fitting, letting in cold air during winter and warm air in summer. All this has allowed a tremendous amount of energy waste in homes across the nation. **Residential energy makes up 20 percent of this country's energy consumption. Approximately 60 percent of this residential use is for space heating and cooling alone. Energy-saving steps, such as installing insulation and adding storm doors and windows, will reduce energy use in existing homes by 25 to 50 percent.**

Knowing how to read an electric meter will also help consumers reduce utility bills. It will enable individuals to maintain a daily record of household power consumption and to understand why more energy is required for various electrical tasks.

(Booklets and folders listed at the end of this section are packed with energy-saving tips that will help lower heating and cooling bills. They are available in quantity from distributors of TVA power.)

Briefly, some of the primary measures that can be taken to avoid energy waste are:

1. Insulate to at least the following minimum standards as recommended in the TVA area: ceilings - R-19; outside walls - R-11; floors - R-11. Higher standards can be justified if fuel and electric rates go higher.

2. Install storm windows and storm doors. (Clear plastic sheets over the windows instead of regular storm windows are easy to install. They don't look as good and are not as durable, but they do a good job of insulating.)
3. Caulk around window and door frames.
4. Install weatherstripping around outside doors.
5. Cover window or wall air conditioner during the winter.
6. Replace cracked or broken windows.

7. Seal all cracks in outside walls.
8. Insulate ductwork in nonconditioned spaces.

As mentioned earlier, most people have been guilty of wasting energy without being aware of it. But learning the ways to stop wasting energy and conscientiously avoiding wasteful habits will help everyone reduce household energy use.

1. Home Heating - There are several energy-saving practices that will help homeowners use their heating system more efficiently.

   a. Set thermostats at 68 degrees F. or lower, and get in the habit of wearing a light sweater or jacket while at home. In the past, many people felt they had to set their thermostat at 72 degrees or higher to be comfortable. But a person wearing a light sweater will be comfortably warm at 68 degrees, while saving dramatically on the heating portion of utility bills. For example, lowering the thermostat from 72 degrees to 68 degrees and leaving it there during cold weather will reduce annual heating costs by about 20 percent. Setting the thermostat at 65 degrees will save an additional 15 percent. People in England and most European countries have always heated their homes to 65 degrees and would be uncomfortable at a higher setting. It's just a matter of getting used to living in a slightly cooler home.

   b. If a home has individual thermostatically controlled heaters in each room (baseboard, ceiling cable, portable or wall heaters), unoccupied rooms should be closed off and the thermostat turned down to 60 degrees or lower.

   c . Open outside doors as infrequently as possible and never leave them open, even for a minute or two, while running out to the mailbox or to get the newspaper. Another bad habit is to stand in the open doorway while talking to friends.

   d. Don't open bedroom windows at night in cold weather. Some people feel they have to open a window at night for "fresh air." Getting that fresh air is expensive if the heating system is on.

   e. Close the fireplace damper when there's not a fire. It's best to use a fireplace during cool days in the spring and fall to take the chill out of the house—when another heating method is not in use, because a fireplace is not efficient. In fact, it can waste energy.

   f. During bright sunny days in winter open draperies and blinds to let in the sun's heat, but keep them closed on the shady side. Also, shut them throughout the house on cloudy days and at night since they act as an insulator against the cold.

   g. There are many days in mild weather when heating during sunlight hours is not needed. Turn off the heat and open some windows to let the outside air keep the home comfortable. Also, there are

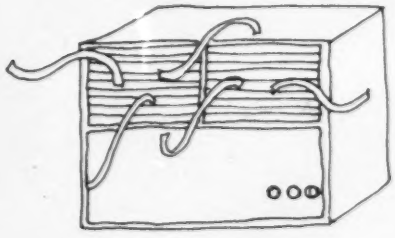
many heat-producing items in the home, such as lights, range, television, dishwasher, washer, dryer, etc., so don't operate a home's heating system if the outside temperature is 65 degrees or above.

h. Lower the thermostat several degrees when the family is away for more than a day.

i. Studies have shown that in cases where no one is at home during the day, considerable savings can be achieved by turning the thermostat down to around 60 degrees when leaving in the morning.

j. The electric heat pump is the most efficient heating system on the market today. It can cut home heating costs by 50 percent. Dealers and power distributors have detailed information about this energy saver.

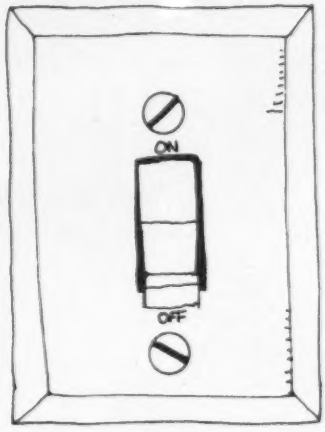
2. Air Conditioning - Cooling doesn't require as much energy as heating, but during hot summer months it can account for a large portion of a power bill. A one-ton air conditioner will use about 1-1/2 kilowatthours for each hour it is operated. A two-ton unit uses twice as much, or three kilowatthours per hour of operation. So, it is important to use air conditioning wisely.



a. Set the thermostat at 78 degrees or higher. An air conditioner does two things that enhance comfort in hot weather. It cools the air and removes moisture. This is really important for home comfort. In a dry atmosphere the moisture on skin can evaporate rapidly, having a cooling effect on the body, even though the room temperature is relatively high. So one will be very comfortable at 78 degrees or higher with the air conditioner running.

b. Close draperies and blinds on the sunny side of the house. This will cut heat transfer through the glass in half.

c. Turn off all unnecessary lights. All the wattage in a light bulb is turned into heat. A 100-watt light bulb puts out 100 watts in the form of heat. It's very unlikely that anyone would ever have thirty-five 100-watt bulbs burning in a home, but if so, it would require one ton of air conditioning just to get rid of the heat from the 35 bulbs.



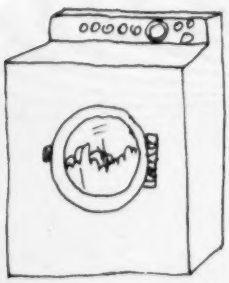
d. Turn off the television when no one is watching it. It produces up to 300 watts of heat.

e. On mild days, turn off the air conditioner and open windows. A window or attic fan will cool a house rapidly after sunset.

f. Clean or change filters on air conditioners regularly. Dirty filters cause the air conditioner to work harder at reduced efficiency and at a higher cost of operation.

3. Conserving Hot Water - The electric water heater in a home works all year round and can use up to 8,000 kilowatt-hours (kWh) annually. Power use depends upon what hot-water-using appliances are in the house and the number of people in the family. The water heater can account for up to 25 percent of the annual electric bills. By getting into the habit of cutting hot water use, people can save considerably on monthly electric bill.

   a. An automatic clothes washer uses about 150 kWh per month. Whenever possible, taking into consideration types and colors of fabrics, water temperature required, etc., wash full loads without packing. Electricity is saved because the washer and hot water are used less often. If washing a small load is a must, select the water level to fit the load. Use warm or cold water whenever possible.

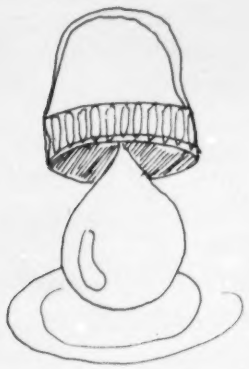


   b. It takes in the neighborhood of 100 kWh to operate an automatic dishwasher each month. After each meal, store dirty dishes in the dishwasher and use the "rinse and hold" setting if it has one. Or, rinse dishes in cold water before loading them in the dishwasher. The full-wash cycle should be reserved for full loads.

   c. About 150-200 kWh per month go for bathing. Take short showers rather than a tub bath. According to the U.S. Department of Agriculture, the average tub bath uses 10 to 15 gallons of hot water and the average shower eight to 12 gallons. And to use even less hot water, turn the shower off when lathering.

   d. Up to 100 kWh used in the home each month fall into the "general" category. Everyone should get in the habit of plugging the sink drain when washing hands and face, shaving, and rinsing dishes. Allowing hot water to pour steadily

down the drain is a very wasteful habit. Replace washers on leaky faucets. A hot water faucet slowly leaking one drop per second wastes 2,500 gallons per year. That's over 600 kWh that the consumer has paid for and wasted.



The Wise Use of Commercial Business Energy

Nearly all commercial buildings are constructed on a speculative basis. Great emphasis is placed on keeping down first costs. This fact often tends to place operating costs on a lower priority. Reducing the initial construction costs of a building results in a reduced appraised value and a lower property tax base. Increased operating and maintenance costs incurred by the owner and tenants can be written off as a business expense on income tax. So there is very little monetary incentive for anyone to construct an energy-saving building.

Legislation has been passed in some states and is being studied in others to limit the heat loss and heat gain in new buildings. Other requirements for holding down energy use are also to be established. Recent changes in the Minimum Property Standards established by the Department of Housing and Urban Development (HUD) will do much to reduce energy waste in new homes.

The amount of energy wasted in commercial buildings varies widely. It depends upon the age of the building, what the building is used for, type of construction, occupant and maintenance practices, operation of equipment, and many other factors. Potentials for saving energy in most buildings are high. These potential areas fall into several categories.

Insulating the Building
Heating, Air Conditioning and Ventilation
Lighting
Water Heating
Food Service
Heat Recovery Systems
General

(TVA folder *Conserving Electricity in Commercial Buildings* gives more detailed information on ways to save energy. Copies are available free from power distributors.)

The Wise Use of Industrial Energy

More than 41 percent of the total energy consumption in the United States is the result of industry. Most industrial energy use is for process steam and direct heat in manufacturing processes.

The efficiency with which fuel is used in various industries differs greatly. Depending on the process, this efficiency can be as low as 20 percent. Although the inefficiency of fuel use has been recognized by industry, it has been—until recently—more economical to permit energy waste. This was because of energy's low cost and abundance. It was less expensive to waste energy than to invest in ways of developing more efficient techniques.

But, due to fuel shortages and rising costs, attention has now been turned to developing and improving the methods of using fuel. Much of this research has been stimulated by industry. Waste heat management programs, instituted by several large corporations, have proven that a savings of seven to 15 percent in the consumption of fuel can be made without sacrificing plant output. Stopping easily correctable wastes of fuel and electric

power through careful thermal management programs will save considerable amounts of energy. Such programs can reduce fuel and power consumption by about 20 percent in existing plants without any reduction in plant yield, according to a Dow Corporation estimate.

Several other studies have shown that new processes already developed or being studied will allow industry to save vast amounts of fuel and electric power.

Many methods have been developed by industry and small business to save fuel and power in regard to efficient lighting. Better furnaces have been produced, and there are several types of heat recovery systems that have been available for years. Interest in these energy-saving devices has risen sharply with the rapid increase of all fuel prices.

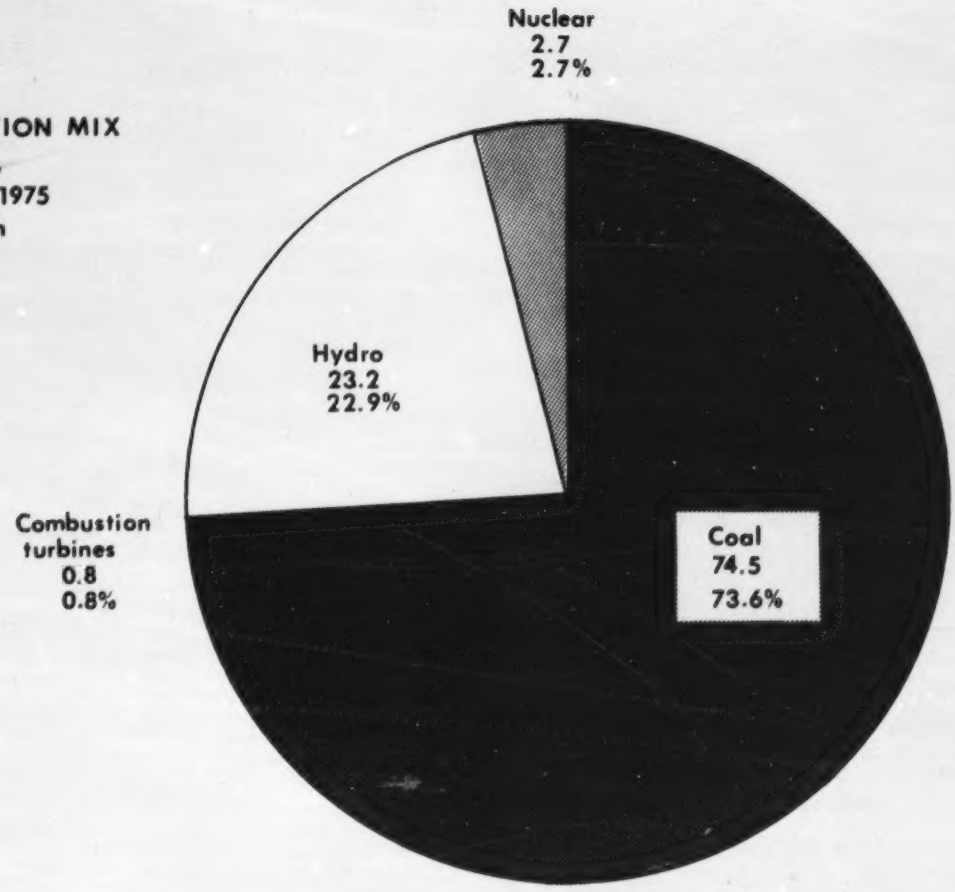
(More information on saving electricity in industry can be found in the folder, *Industrial Guide for Electricity Conservation.* Quantity supplies of these folders are available at no cost from the distributors of TVA power.)

If America can reduce oil demand in the 8-9 million barrels per day range, it can meet the total energy needs from domestic sources. However, total independence of foreign fuels may never be advisable because of economic and political factors.

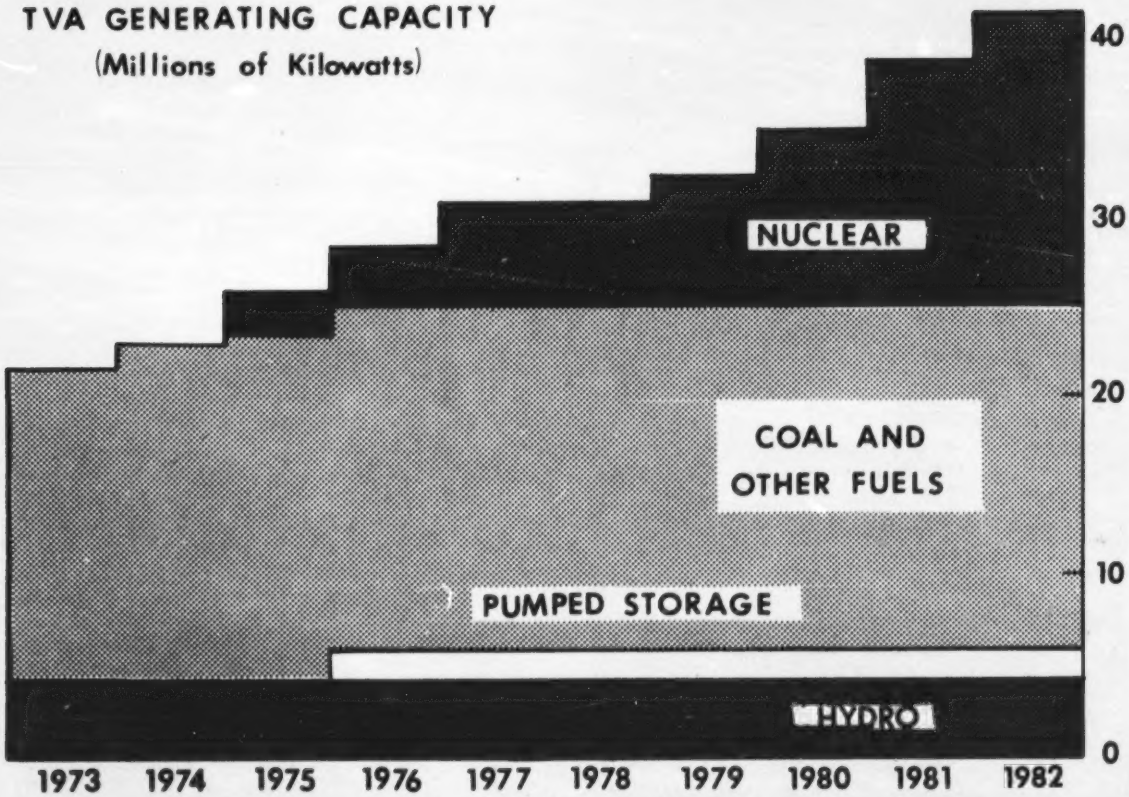
In any case, if the U.S. is to reach energy self-sufficiency, or even come close to it, the domestic supply must be stretched broadly. Much of the increase will have to be borne by the electric utility industry and by its mining associates in coal and uranium. The balance will have to come from the petroleum industry, which will have to double in size within the next 11 years in order to realize a net 25 percent increase in supply. Existing fields, which in 1973 produced 10.1 MBPD* of oil and 67 BCFD** of gas, are expected to decline by 6 MBPD of oil and 39.4 BCFD of gas by 1985. Actually, the decline would be steeper. But with higher values on output, secondary recovery processes will be applied to squeeze every drop from the deposit. In short, a continued program of energy conservation for this country is essentially compulsory.

*MBPD - million barrels per day.
**BCFD - billion cubic feet per day.

Chart VII-1
TVA GENERATION MIX
Net Generation,
Calendar Year 1975
Billions of kWh



Graph VII-2
TVA GENERATING CAPACITY
(Millions of Kilowatts)



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A Guide to Home Climate Control
Annual Electric Energy Use and Cost Chart
Become a No. 1 Energy Owl (word game)
Conserve Energy and Save Money by Using Electricity Efficiently
Conserving Electricity in Commercial Buildings
Danger, High Voltage
Detecting and Controlling Moisture Problems in the Home
Guide for Buying an Electric Dishwasher
Guide for Buying an Electric Heat Pump
Guide for Buying an Electric Range
Guide for Buying an Electronic Oven
Guide for Buying a Food Disposer
Guide for Buying a Refrigerator and Freezer
Guide for Buying a Room Air Conditioner
Guide for Buying a Trash Compactor
Guide for Buying a Washer and Dryer
Heat Pump, the Energy Miser
Industrial Guide for Electricity Conservation
Installing Home Insulation
Insulate for Savings and Comfort
Stop Shock
Super Saver Electric Home
The Electric Energy Management Program
The Portable Electric Space Heater
What's Your Energy EQ (game)
Which Three? (game)
Your Electric Meter and How to Read it
Materials for limited income consumers

VIII. STUDENT PARTICIPATION AND DISCUSSION ACTIVITIES

1. Using the 29 point check list (available from your power distributor or TVA), make an energy audit of your home.

2. Complete the "Energy Owl" puzzle. (This puzzle is available from your power distributor)

3. Compose short stories or skits around possible results of energy failure, or the energy conservation effort.

4. Conduct an essay contest on the need for conserving all forms of energy.

5. Have students secure or build an insulation demonstrator. (Materials needed: shoe box; thermometer; light bulb; different forms of insulation, such as fiberglass, styrofoam, mineral wool, etc.)
   a. Devise as many variations as possible of testing different insulating materials and combinations thereof.
   b. Use temperatures both inside and immediately outside the demonstrator.

6. Ask students to evaluate the purchase of a home from an energy consumption point of view (i.e., insulation, cubic feet, storm windows, effective heating system, length of hot water lines and their insulation, etc.)

7. Conduct an energy audit of your school. Divide the class into groups of four or five students each. Have each group study and make a record of all the energy (oil, coal, gas, electricity, etc.) used in operating the school building. These operating categories could be as follows:
   a. Heating and cooling
   b. Lighting
   c. Cafeteria operations
   d. Water heating
   e. Miscellaneous (audio-visuals, etc.)

   In making the audit, each group should look for and make a record of ways in which energy is being wasted, such as dripping hot water faucets, lights left on in unoccupied rooms, unnecessarily high temperatures, faulty controls on heating or cooling systems, etc. At the end of the audit (a week or a month) prepare a report of the findings with an evaluation of how much energy has been used and how much has been wasted.

GLOSSARY OF TERMS

BARREL - The international unit for crude oil or petroleum products—one barrel equals 42 gallons.

BRITISH THERMAL UNIT (Btu) - The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

CARRIER WATER - Water used to hold pulp particles in suspension and for distribution over a moving screen in paper making.

COMBINED CYCLE - The utilization of heat from large gas turbines to generate steam for conventional turbines.

DIRECT HEAT - Heat applied in industrial processes to increase the temperature of liquids or solids.

ENERGY - The ability to do work, or to make things move.

ENERGY, PRIMARY - Energy in its naturally occurring form—coal, oil, uranium, etc.

FISSION - The splitting of heavy nuclei into two parts with the release of large amounts of energy and one or more neutrons. The emitted neutrons can be absorbed by and initiate fission in other, similar, nearby nuclei, thus producing a chain reaction.

FOSSIL FUEL - Any naturally occurring fuel such as coal, crude oil, or natural gas, formed from the fossil remains of organic materials.

GEOTHERMAL - The heat energy in the earth's crust, which has its source from the earth's molten interior. When this energy occurs as steam, it can be used directly in steam turbines.

MEGAWATT (MW) - A unit of power. A megawatt equals 1,000 kilowatts, or 1 million watts.

OIL SHALE - A sedimentary rock containing a solid organic material called kerogen. When oil shale is heated to high temperatures, the oil is driven out and can be recovered.

PHOTOVOLTAIC - Converting light directly into electricity—it is the major solar cell, semiconductor device.

R-VALUE (RESISTANCE) - A unit of measurement that indicates the difficulty a unit of heat has in flowing through a given material.

REACTOR, BOILING WATER (BWR) - In this reactor, heat is created by controlled nuclear fission in the core of the reactor. The heat produces steam, which is used to drive a turbine.

REACTOR, PRESSURIZED WATER (PWR) - Operating at a higher pressure than the boiling water reactor, this type also produces heat by nuclear fission in the core. Because of the higher pressure, the water does not boil in the reactor vessel. The water boils in an exterior heat exchanger, supplying steam to the turbine.

REACTOR, HIGH TEMPERATURE GAS (HTGR) - A nuclear reactor which differs from boiling water reactors in having graphite as a moderator, and helium as a coolant.

REACTOR, LIQUID METAL FAST BREEDER (LMFBR) - A nuclear breeder reactor cooled by molten sodium. The heat produced by fission in the core is transferred by the sodium to an exterior heat exchanger in a closed circuit. Water in the second closed circuit in the heat exchanger is converted to steam to power the turbine. The reactor uses uranium 235 or plutonium 239 as fuel and produces additional plutonium 239 from nonfissionable uranium 238 in a "blanket" around the reactor core.

STEAM, WET - Basic steam, also called saturated steam. None of the water content has been removed.

STEAM, DRY - Steam that has been superheated to reduce the water content. This is a higher temperature and pressure steam.

STEAM, PROCESS - Wet steam used in various industrial processes, including product drying, space heating, etc.

TAR SANDS - A sandy geologic deposit in which oil is found. The oil binds the sand together.

THORIUM - A radioactive tetravelant, metallic element that occurs, combined in minerals such as granite. It is usually associated with rare earths.